

Income change after cruciate ligament injury – A population-based study ☆☆☆☆



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ABSTRACT

Objectives: To investigate the association between choice of treatment and patients' income after cruciate ligament (CL) injury and assess the effect of different covariates such as sex, age, comorbidities and type of work.

Methods: This entire-population cohort study in Sweden included working patients with a diagnosed CL injury between 2002 and 2005, identified in The National Swedish Patient Register (n = 13,662). The exposure was the treatment choice (operative or non-operative treatment). The main outcome measure was average yearly income five years after CL diagnosis, adjusted for the following covariates: sex, age, comorbidities, type of work, region, calendar year, education and income.

Results: Relative to non-operative treatment, operative treatment was associated with greater average yearly incomes (nine to 15%) after injury among patients between 20 and 50 years, patients with partial university education, patients living in large cities and patients with one comorbidity, despite no overall significant association in the national cohort. Delayed operative treatment (>1 year) had no significant association with income change, whereas early operative treatment (<1 year) was associated with higher average yearly incomes (11 to 16%) among females, patients between 20 and 50 years, patients living in large cities and patients with one comorbidity.

Conclusions: In a broad sense, treatment choice was not associated with changes in income five years after CL injuries among patients in the workforce, however earlier operative treatment

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was associated with higher average incomes among patients with ages between 20 and 50, females, living in large cities, with one comorbidity and with a high level of education.

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1. Introduction

Cruciate ligament (CL) tears in the knee are common musculoskeletal injuries with a yearly incidence of 78/100,000 in Sweden [1]. Immediate CL reconstruction (CL-R) is usually reserved for specific groups of patients such as elite athletes [2–6] especially since other potential operative indications (e.g. avoiding osteoarthritis) have been challenged [7]. In such conditions, where death is not a relevant outcome measure and the indications for more aggressive treatment include relative or subjective symptomatology (i.e. symptomatic surgery), a deeper understanding about how these conditions affect other non-clinical outcomes is warranted. This is particularly interesting in orthopedics since pain and other symptoms from the musculoskeletal system are the most frequent causes of long-term sickness absence and loss of productivity [8,9]. Hence restoring optimal physical function is critical for peak productive performance within certain professional activities. For this reason, it is reasonable to argue that returning to a productive life could be considered as a relative indication for more aggressive treatment in specific musculoskeletal conditions. It is therefore interesting to study an alternative outcome, such as the change in socioeconomic status (SES) after orthopedic treatments [10]. To our knowledge, no studies analyze the association between CL treatment to individual patient's economics. Therefore, this population-based cohort study is primarily aimed to evaluate the association between patients' income after a CL injury and the type of treatment chosen. By including relevant covariates, we also aim to present results that can be used to develop guides for the decision-making process, taking the first steps towards a more personalized type of care.

2. Methods

2.1. Setting and data

We conducted a nationwide, cohort study in Sweden using data ranging from 2001 to 2010 from the Swedish National Patient Register (NPR) which has nationwide coverage for all inpatient and outpatient visits and is of very high validity [11]; and the Longitudinal Integration Database for Health Insurance and Labor Market Studies (LISA) integrating existing data from registers on the labor market, education, and social sectors including reported incomes [12]. Further details from these registries are described in our previous work [13].

2.2. Participants

The cohort included all inhabitants of Sweden with a diagnosed CL injury of the knee who were part of the workforce at the time of injury. We identified patients with a recorded first-time diagnosis of CL injury (ICD-10: S835, M235) during the years 2002–2005 ($n = 40,684$). To focus on the workforce, we excluded patients over 60 years, under 16 years, students and retired. A total of 13,662 patients were included in our analysis (Figure 1). For further details of the inclusion and exclusion process please see the supplementary material.

2.3. Exposure and outcome

The exposure was defined as the choice of treatment (operative or non-operative treatment). We further classified CL-R into those who received early operative treatment (within a year of diagnosis) and late operative treatment (over one year after diagnosis). The primary outcome was defined as the patient's average yearly disposable income in Swedish crowns (SEK) as registered in the LISA database, over a span of five years after diagnosis.

2.4. Statistical analysis

An analysis of covariance (ANCOVA) – with a logarithmic transformation of the dependent variable and using least square means – was used to estimate the association between CL treatment and average yearly income after diagnosis. Several covariates were included in the analysis to control for confounding biases and effect modifications (see supplementary material for details): injury year, pre-injury income, sex and age, professional activities, highest achieved educational level, region of residence, meniscus injury and comorbidities (Figure 2). Detailed descriptions of the covariates can be found in the supplementary material. All covariates were included based on clinical knowledge and kept in the analysis regardless of statistical significance. Additionally, the interactions between CL-reconstruction and all categorical covariates (except year of injury) were also included in the analysis to study the magnitude of the effect modification that these covariates have on the exposure. All statistical analyses were performed with SAS software version 9.2 (SAS Institute, Cary, North Carolina), using 95% confidence intervals and treating p -values < 0.05 as representing statistical significance.

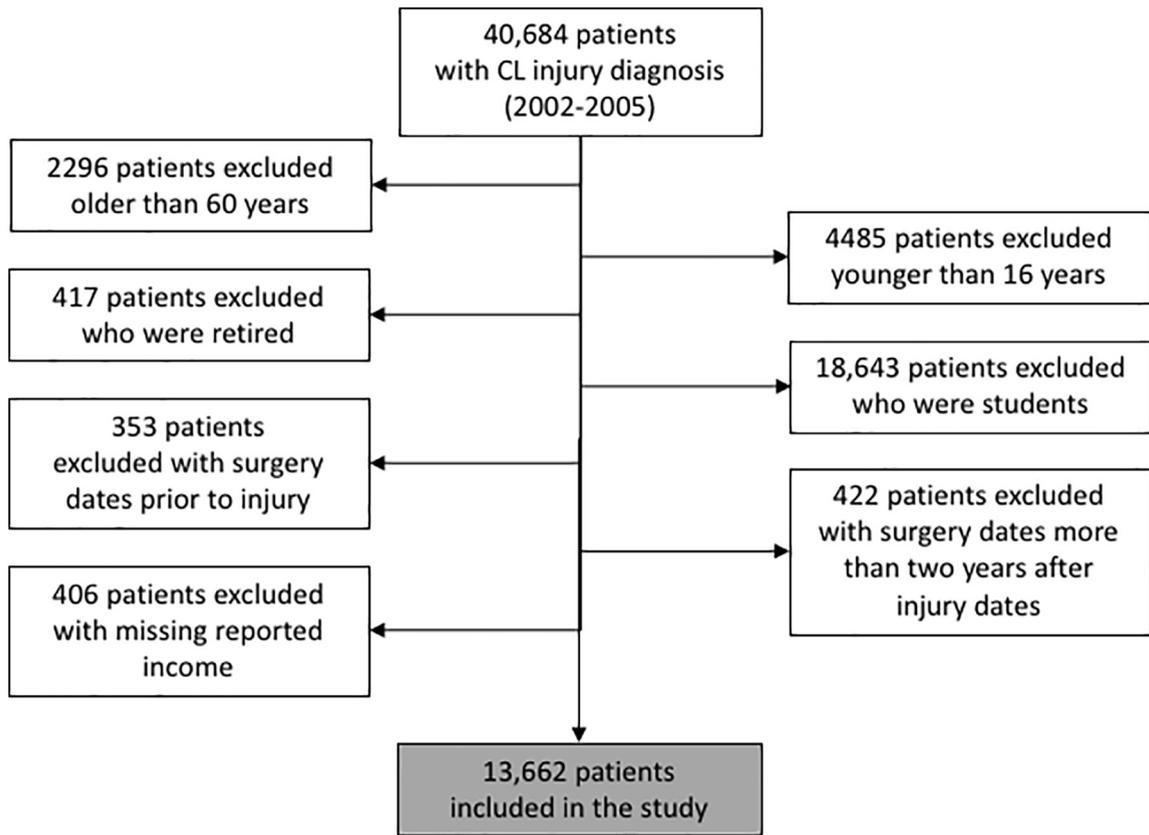


Figure 1. Definition of the study population.

2.5. Ethical statement

All registry information was anonymized and de-identified by the Swedish National Board of Health and Welfare prior to analysis. This study was approved by the regional Ethics Committee in Stockholm (Dnr: 2010/1713-32).

3. Results

3.1. Description of the population

A total of 13,662 patients were included with a mean age at time of diagnosis of 37 years. Patients aged 31 to 40 years represented the largest group (38%) and women represented 33% (Table 1). Patients who underwent CL-R comprised 31% of the study population (n = 4,283). As much as 7% were diagnosed with comorbidities, with depression, alcohol abuse, hypertension

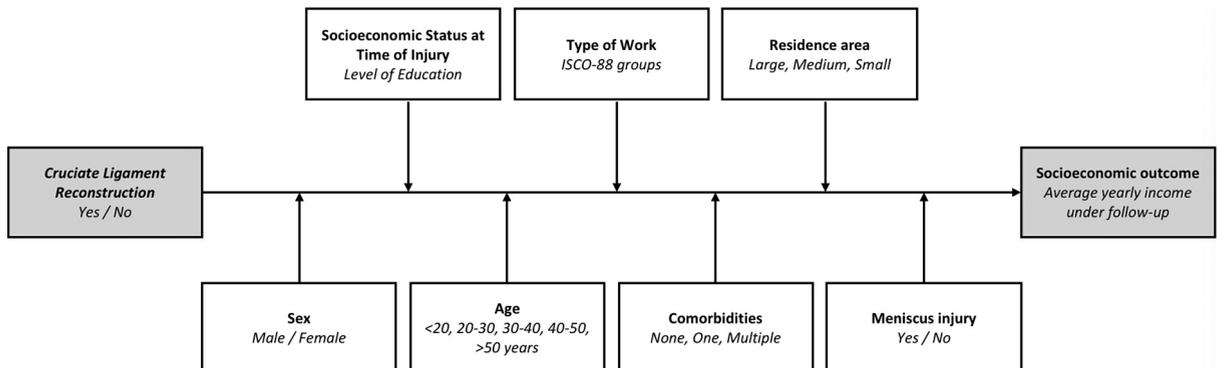


Figure 2. The model of the study for income.

Table 1
Description of the study population.

	Total		No CL-R		CL-R	
N (%)	13,662	(100)	9379	(69)	4283	(31)
Females; N (%)	4542	(33)	3264	(35)	1277	(30)
Age; mean (\pm SD)	36.96	(\pm 9.2)	38.75	(\pm 9.4)	33.06	(\pm 7.7)
Range	16–60		16–60		17–58	
Age group; N (%)						
<20	150	(1)	86	(1)	64	(1)
21–30	3699	(27)	1951	(21)	1748	(41)
31–40	5124	(38)	3394	(36)	1730	(40)
41–50	3433	(25)	2784	(30)	649	(15)
>50	1256	(9)	1164	(12)	92	(2)
Education Level; N (%)						
Junior high school or less	1613	(12)	1252	(13)	361	(8)
Partial high school education	4181	(31)	3074	(33)	1107	(26)
High school graduation	3476	(25)	2132	(23)	1344	(31)
Partial collage/university education	1923	(14)	1323	(14)	600	(14)
College/university graduation	2395	(18)	1542	(16)	853	(20)
Not known/not reported	74	(1)	56	(1)	18	(0)
Income ^a ; mean (\pm SD)	1955.60	(\pm 2558.8)	1959.41	(\pm 2938.7)	1947.25	(\pm 1405.2)
Range	0–199,858		0–199,858		0–51,943	
Type of work; N (%)						
Legislators, senior officials and managers	695	(5)	500	(5)	195	(5)
Professionals	2153	(16)	1443	(15)	710	(17)
Technicians and associate professionals	2561	(19)	1669	(18)	892	(21)
Clerks	923	(7)	631	(7)	292	(7)
Service workers and shop and market sales workers	1806	(14)	1244	(13)	562	(13)
Skilled agricultural and fishery workers	125	(1)	94	(1)	31	(1)
Craft and related trades workers	1814	(13)	1237	(13)	577	(13)
Plant and machine operators and assemblers	1668	(12)	1119	(12)	549	(13)
Elementary occupations	584	(4)	408	(4)	176	(4)
Armed forces	76	(1)	51	(1)	25	(1)
Not known/not reported	1257	(9)	983	(10)	274	(6)
Residence area; N (%)						
Large	5267	(39)	3458	(37)	1809	(42)
Medium	6750	(49)	4722	(50)	2028	(47)
Small	1371	(10)	992	(11)	379	(9)
Not known/not reported	274	(2)	207	(2)	67	(2)
Comorbidities; N (%)						
None	12,639	(92)	8548	(91)	4091	(93)
Single	768	(6)	614	(7)	154	(4)
Multiple	255	(2)	217	(2)	38	(1)
Meniscus Injury; (N) %	8283	(61)	5446	(58)	2837	(66)

^a Mean disposable income the year before injury (in hundreds of Swedish Crowns).

and diabetes among the most frequent. The average time from injury to surgery was 232 days (SD \pm 364) (about 7.5 months) with about 19% of patients with a time longer than 12 months.

3.2. Income after treatment

Operative treatment was associated with a higher average yearly income compared/relative to those who received conservative treatment (RR 1.06; 95% CI 1.04–1.08), though after adjusting for all covariates the ratio was non-significant (RR 1.08; 95% CI 0.99–1.17). In the stratified analysis of all the covariates we observed that almost all subgroups showed a numerically positive association between operative treatment and income, although most were not statistically significant. Notably, among patients between 20 and 50 years, those in the CL-R group were associated with nine percent higher average yearly incomes, as well as patients living in large residence areas (12%), patients with partial university education (10%) and patients with one comorbidity (15%) but not multiple comorbidities. All other covariates yielded statistically non-significant results (Table 2).

3.3. Income after early vs. late operative treatment

When subcategorizing the patient group treated operatively (early and late operative treatment), we observed that results were similar to those reported above if patients belonged to the early operative treatment group (<12 months). Those treated late (>12 months), showed no difference in income change compared with those who had non-operative treatment overall and on the stratified analysis (Table 3). Notably, early operative treatment (<12 months) among females was associated with higher average yearly incomes (11%) as well as patients between 20 and 50 years (11–12%), patients living in large residence

Table 2
Relative ratio of the yearly average income of operative treatment, stratified by covariates.

	No CL-R		CL-R	
	RR ^a	95% CI	RR	95% CI
Unadjusted	1 (Reference)	–	1.06	(1.04–1.08)
Adjusted ^b	1 (Reference)	–	1.08	(0.99–1.17)
<i>Sex</i>				
Male	1 (Reference)	–	1.07	(0.98–1.16)
Female	1 (Reference)	–	1.09	(0.99–1.19)
<i>Age group</i>				
<20 years	1 (Reference)	–	0.98	(0.84–1.16)
20–30 years	1 (Reference)	–	1.09	(1.00–1.19)
30–40 years	1 (Reference)	–	1.09	(1.01–1.19)
40–50 years	1 (Reference)	–	1.09	(1.00–1.19)
>50 years	1 (Reference)	–	1.13	(0.99–1.27)
<i>Residence area</i>				
Large	1 (Reference)	–	1.12	(1.04–1.22)
Medium	1 (Reference)	–	1.06	(0.98–1.15)
Small	1 (Reference)	–	1.05	(0.96–1.16)
<i>Education Level</i>				
Junior high school	1 (Reference)	–	1.09	(0.99–1.19)
Partial high school	1 (Reference)	–	1.07	(0.99–1.16)
High school graduation	1 (Reference)	–	1.08	(0.99–1.17)
Partial university education	1 (Reference)	–	1.10	(1.00–1.20)
University graduation	1 (Reference)	–	1.05	(0.96–1.15)
<i>Type of work</i>				
Legislators, senior officials and managers	1 (Reference)	–	1.00	(0.90–1.12)
Professionals	1 (Reference)	–	1.04	(0.95–1.14)
Technicians and associate professionals	1 (Reference)	–	1.05	(0.96–1.15)
Clerks	1 (Reference)	–	1.05	(0.94–1.16)
Service workers and shop and market sales workers	1 (Reference)	–	1.04	(0.95–1.14)
Skilled agricultural and fishery workers	1 (Reference)	–	1.13	(0.93–1.38)
Craft and related trades workers	1 (Reference)	–	1.06	(0.96–1.16)
Plant and machine operators and assemblers	1 (Reference)	–	1.07	(0.97–1.18)
Elementary occupations	1 (Reference)	–	1.05	(0.94–1.17)
Armed forces	1 (Reference)	–	1.09	(0.87–1.37)
<i>Meniscus tear</i>				
Yes	1 (Reference)	–	1.08	(0.99–1.18)
No	1 (Reference)	–	1.07	(0.98–1.17)
<i>Comorbidities</i>				
None	1 (Reference)	–	1.02	(0.95–1.09)
One	1 (Reference)	–	1.15	(1.04–1.27)
Multiple	1 (Reference)	–	1.07	(0.91–1.26)

^a Relative ratio of the yearly average disposable income during the first five years after the year of injury (No CL-R group used as reference).

^b Adjusted for sex, age groups, region of residence, type of work, comorbidities, level of education, year of injury and income the year before injury (all stratified results shown were obtained using the adjusted analysis).

areas (15%), and patients with one comorbidity (16%) in comparison with non-operative treatment (Table 3). When comparing directly early to late operative treatment, we observed no statistically significant associations.

4. Discussion

This nationwide cohort study including the whole population of Sweden did not show any clear association between CL-R and overall average yearly income five years after CL injury. However, by including covariates of importance, our analysis enables potential identification of subgroups that would possibly benefit most from operative treatment. Among patients between 20 and 50 years of age, patients living in large residence areas, patients with partial university education or patients with one comorbidity, operative treatment was associated with higher average yearly income after injury. Similarly, early operative treatment was associated with higher incomes in the same subgroup of patients as well as females.

4.1. Income after treatment

Overall, treatment choice was not clearly associated with better outcomes in terms of average yearly income in this nationwide cohort. Musculoskeletal conditions are an important cause of sickness absence [14] and the percentage of patients returning

Table 3

Relative ratio of the yearly average income of early and late operative treatment subgroups, stratified by covariates.

	CL-R < 12 months		CL-R > 12 months	
	RR ^a	95% CI	RR	95% CI
Unadjusted	1.07	(1.05–1.09)	1.02	(0.98–1.06)
Adjusted ^b	1.10	(0.99–1.20)	1.02	(0.86–1.21)
<i>Sex</i>				
Male	1.80	(0.99–1.19)	1.02	(0.86–1.21)
Female	1.11	(1.01–1.22)	1.02	(0.86–1.22)
<i>Age group</i>				
<20 years	1.02	(0.85–1.21)	0.85	(0.60–1.19)
20–29 years	1.11	(1.01–1.22)	1.09	(0.93–1.29)
30–39 years	1.12	(1.02–1.22)	1.05	(0.89–1.23)
40–49 years	1.12	(1.01–1.23)	1.03	(0.86–1.22)
>50 years	1.13	(0.99–1.30)	1.11	(0.89–1.40)
<i>Residence area</i>				
Large	1.15	(1.05–1.26)	1.04	(0.88–1.22)
Medium	1.08	(0.99–1.18)	0.99	(0.84–1.17)
Small	1.07	(0.96–1.18)	1.02	(0.84–1.22)
<i>Education Level</i>				
Junior high school	1.10	(0.99–1.21)	1.08	(0.90–1.29)
Partial high school	1.08	(0.98–1.18)	1.09	(0.93–1.29)
High school graduation	1.09	(0.98–1.23)	1.04	(0.85–1.27)
Partial university education	1.13	(0.99–1.19)	1.05	(0.88–1.25)
University graduation	1.07	(0.97–1.17)	0.99	(0.83–1.18)
<i>Type of work</i>				
Legislators, senior officials and managers	1.03	(0.91–1.16)	0.89	(0.70–1.13)
Professionals	1.04	(0.94–1.16)	1.03	(0.85–1.24)
Technicians and associate professionals	1.07	(0.95–1.21)	1.01	(0.84–1.21)
Clerks	1.06	(0.96–1.16)	0.93	(0.76–1.14)
Service workers and shop and market sales workers	1.05	(0.95–1.17)	0.94	(0.79–1.13)
Skilled agricultural and fishery workers	1.15	(0.93–1.42)	1.03	(0.67–1.58)
Craft and related trades workers	1.09	(0.98–1.21)	0.91	(0.76–1.10)
Plant and machine operators and assemblers	1.10	(0.99–1.22)	0.92	(0.77–1.11)
Elementary occupations	1.06	(0.94–1.20)	0.94	(0.77–1.15)
Armed forces	1.15	(0.91–1.46)	1.53	(0.94–2.48)
<i>Meniscus injury</i>				
Yes	1.10	(0.99–1.21)	1.04	(0.88–1.23)
No	1.10	(0.99–1.21)	1.00	(0.84–1.20)
<i>Comorbidities</i>				
None	1.03	(0.96–1.11)	1.08	(0.90–1.30)
One	1.16	(1.04–1.30)	0.89	(0.65–1.22)
Multiple	1.10	(0.92–1.32)	0.98	(0.86–1.12)

^a Relative ratio of the yearly average disposable income during the first five years after the year of injury (No CL-R group used as reference).

^b Adjusted for sex, age groups, region of residence, type of work, comorbidities, level of education, year of injury and income the year before injury (all stratified results shown were obtained using the adjusted analysis).

to work after a lower extremity injury can be 58% at three months and 77% at 12 months [15]; with hematoma or effusion and pain inside the knee being the most important factors affecting return to work for physically demanding jobs [16]. Surgery may allow a faster return to professional activities and habitual productivity [17,18], hence it is easy to speculate that those patients who more rapidly return to work, whether it is due to surgery or other factors, will suffer lesser losses in their annual incomes as compared with those who returned to work at a slower pace. Our results cannot confirm this hypothesis since return to work time was not included in the analysis. Besides, CL rupture may not be a sufficiently disabling injury. Still, another study in total knee replacements – a more disabling condition – also failed to find an effect of treatment over SES [10]. Nonetheless, we included type of work as a covariate in our analysis in an attempt to control for variations in the degree of physical exertion inherent to every type of work, this still did not seem to affect the overall results. This may seem contradictory to a recent study that found that the odds for fully returning to work early (≤ 78 days) after an ACL surgery were more than five times greater for patients who had less knee-demanding or light workload compared with those with heavier workloads, though without including conservatively treated cases [18]. The association between the time to return to work and income was out of the scope of our study. It would be interesting for future studies to analyze whether CL reconstruction allows for sooner return to work and whether this intervention translates into better incomes. One particular study came close while analyzing so-called indirect costs after an ACL injury (i.e. household income, missed work days and disability payments), although as a supplemental analysis,

estimating that patients who received non-operative treatment for ACL injury had increased indirect costs compared with ACL reconstruction (measured as income loss, disability compensation and days loss of work) [19].

Even when adjusted for socioeconomic variables, like baseline income and education, the current study still found a positive effect for operative treatment among patients living in large cities (RR 1.12; 95% CI 1.01–1.24). This suggests that living in a larger city perhaps holds an additional significance than just a SES variable. It would be interesting to evaluate the role that access to care and surgeon/hospital operative volumes play on these outcomes, however this was out of the scope of the current study. The risk of a population bias is real, and although we controlled for several covariates, unnoticed features related to highly populated areas may still be able to modify the effect. A recent study has shown that patients living in nonurban areas were 94% more likely to use low-volume hospitals [20] and it has been argued that hospitals with larger surgical volumes of a certain procedure tend to produce better outcomes [21–23]. Other not-explored speculations to explain this effect may lie in the diversity of the population that exists in big cities as compared to nonurban areas, where seven to 10% of the population in the three largest Swedish cities (Stockholm, Malmö and Gothenburg) was composed of inhabitants born outside Sweden compared to five percent in the rest of the country (Statistics Sweden).

Age was another covariate that showed that operative treatment was associated with higher income in our study. Operative treatment of ACL ruptures in young adults (late teens and 20s), was more cost-effective than conservative treatment [24]. Another study that evaluated blunt orthopedic trauma revealed that financial losses appear to be common in patients between 19 and 50 years [25]. In a similar way, our study showed that among young patients (between 20 and 30 years) early operative treatment seemed to have a positive association with income, but so did also the subsequent groups up to 50 years of age. Possibly a group of younger patients (<20 years) would also behave in such a way, however our study is really scraped in this demographic since most patients in this age group would be students and as such not be considered part of the workforce and were thus excluded from our analyses. Patients in this range of ages (20–50) may be more vulnerable to changes in their physical condition as they are likely to have only one source of income that depends on their work attendance. Finally, we demonstrated that operative treatment was associated with better income in patients with one comorbidity but not multiple. Few studies have analyzed comorbidities in relation to CL injuries. One recent study done in the Danish Knee Ligament Reconstruction Register found that most of the comorbid conditions did not affect the risk of revision surgery, except for diseases of the back or back pain which increased the risk [26]. However, another study has demonstrated that comorbidities can confound outcome measures after ACL injuries [27]. This is supported by other studies which show that comorbidities such as depression, diabetes and hyperuricemia are associated with poor outcomes after ACL injury [28–30]. An association between surgery and income was not present among patients with multiple comorbidities. No previous studies have analyzed this; however, we can speculate that this was observed because the burden of several comorbidities is greater than any benefits that the treatment for CL injury can offer.

4.2. Income after early vs. late operative treatment

The subgroup containing patients who had early operative treatment (<12 months) differed from the non-operated group, and these differences were not found with the late operative treatment subgroup (>12 months), suggesting that the effect that operative treatment has over income is stronger during the first year after injury. This may be due to the amount of sick leave days that are taken during the early stage in the latter group, as demonstrated by a well-performed RCT conducted in Sweden, patients who underwent acute reconstruction (<8 days after injury) required less sick leave compensation than those who underwent delayed reconstruction (six to 10 weeks after injury) [31]. In Sweden, sick leave compensation is calculated to be 80% of the patient's previous salary (Swedish Social Insurance Agency), which translates in an instant reduction of salary, one of the main determinants of disposable income. Other studies, while performed in younger patients, demonstrate that a delay in ACL reconstruction is associated with an increase in the prevalence and severity of concomitant meniscal and chondral injuries, which may in turn portend worse long-term prognoses, increase future medical expenses and need for additional surgery [32,33].

The stratification of the analysis showed that among females, early operative treatment was associated with 13% higher incomes, but not late operative treatment. Previous systematic reviews failed to demonstrate clear differences in outcomes of ACL reconstruction between sexes [34,35], suggesting that perhaps the income differences we observed may be related more closely to other patient-specific variables than the functional or clinical outcomes of operative treatment; which in turn argues for the value in studying alternative outcomes.

4.3. Strengths and limitations

The strength of this study is that the complete national coverage of the Swedish registries and the possibility of interlinkage between them, provides a full inclusion of all patients and full availability of all data, substantially reducing the possibility of selection bias, which can occur in observational studies. Moreover, we attempt to further minimize this potential effect with an analysis that includes controls for several relevant covariates. The use of registries also provides some minor disadvantages, such as the fact that researchers are limited to the available data and the method used to record it. One example of this is the potential misclassification of CL injury, since the registry does not include information about criteria or diagnostic methods. The ICD-10 classification does not allow for distinction between anterior cruciate ligament (ACL) and isolated posterior cruciate ligament (PCL) that based on previous literature accounts for three percent of all CL-injuries [36]. Moreover, bilateral injuries (referring to about two percent of the cohort) [37] cannot be individually identified from this registry. However, we have no reason to believe that this misclassification is not random between the groups and therefore the effects on our results would most

likely be an underestimation of the effects. Another example of the data limitation is that there is no standardization of the treatment options, where operative treatment could include several surgical techniques and non-operative treatment could range from rest to aggressive early rehabilitation. There is always a possibility of registration bias with registries, however the NPR has been well-scrutinized achieving a validation of as high as 95% [11]. Similarly, as is the case with observational studies, no causation claims can be drawn from these results. Since the analysis studies the effect of treatment in the workforce, it is not applicable for patients who are students, excluding a large quantity of the younger population which corresponds to a substantial portion of patients with CL injuries. While the inclusion of a high number of covariates could possibly harm the power of our study, we believe that the power is adequate based on the population nature of our cohort together with the benefits of having a high number of participants.

4.4. Study significance

The majority of studies show that ACL reconstruction is cost effective and also improves quality of life of patients on an individual level as compared with non-operative measures [19,38,39]. Nationwide population-based studies are however scarce. To the extent of our knowledge, a similar analysis that could be directly compared with our results has not been published before. In addition, many studies analyze the cost-effectiveness of ACL reconstruction using only societal costs and disease burden indicators (e.g. quality-adjusted life-years, QALYs), without taking into account the individual socioeconomic significance to the patients [38,40–42]. Our study can provide such insight, thus adding to the knowledge of CL injury outcomes while at the same time providing a population-based validation and a stratification of the population which allows individualized forecasting of outcomes. The magnitude of some of our results was not large enough to suggest that real-life effects would be considerable. This may happen since a CL injury is not severely detrimental to income, but other more debilitating musculoskeletal conditions may well be so. If a similar idea is replicated using other more prevalent or more disabling musculoskeletal conditions such as low back pain or final joint failure requiring joint replacement – where lost wages and reduced productivity are deemed to be among the highest [43] – the effect would probably be larger. Moreover, during the decision-making process, a clear definition of successful outcome may require an individualized approach that combines patients' as well as surgeons' views [44]. A recent study, using data from the KANON trial, employed a similar thought approach analyzing the individual characteristics of patients with an ACL injury and how they affect the prognosis of treatment (operative vs. non-operative) and advocates that the decision to delay operative treatment should be taken on an individualized basis [45].

Even though this study did not use a prediction methodology, it could still add important information while introducing the study of covariates and their interactions with socioeconomic outcomes, which altogether could be used in the personalized decision-making process by considering individual patient qualities and could be also included as predictor variables in future prediction models. All this information may be useful in identifying individuals who may benefit most from non-operative or operative treatment of CL injuries.

5. Conclusions

In our nationwide study, treatment choice was not associated with changes in income after CL injuries among patients in the workforce in this national cohort. However, operative treatment, especially earlier operative treatment, was associated with higher average incomes among patients with ages between 20 and 50, females, living in large cities, with one comorbidity and with a high level of education.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.knee.2019.04.003>.

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